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Impacts of Sound on Marine Mammals: Non-auditory Physical Impacts

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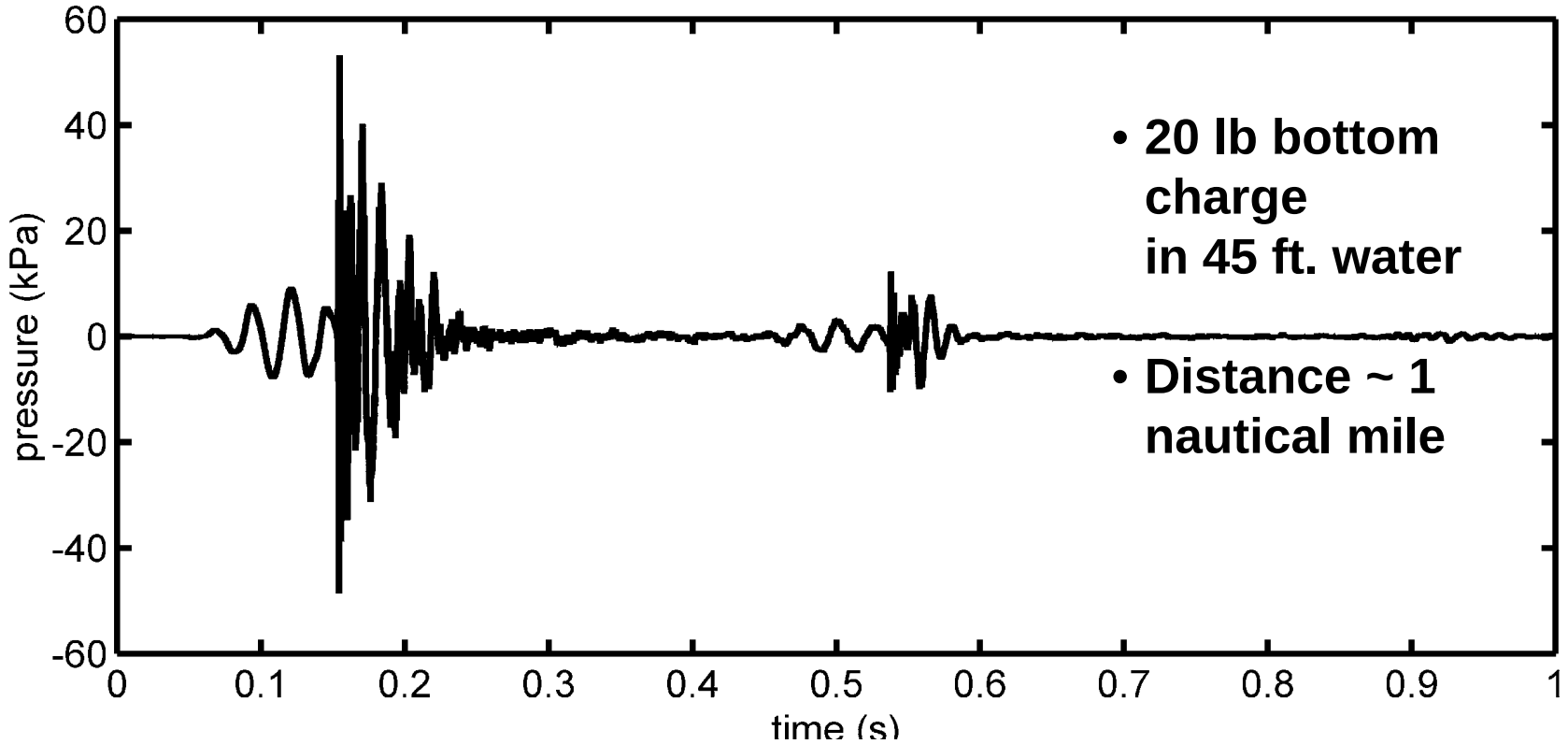
SPAWAR
Systems Center
San Diego

Explosion Example: Churchill (DDG 81) shock trial

U.S. NAVY
MARINE MAMMAL
PROGRAM
BIOSCIENCES DIVISION

Small Explosion

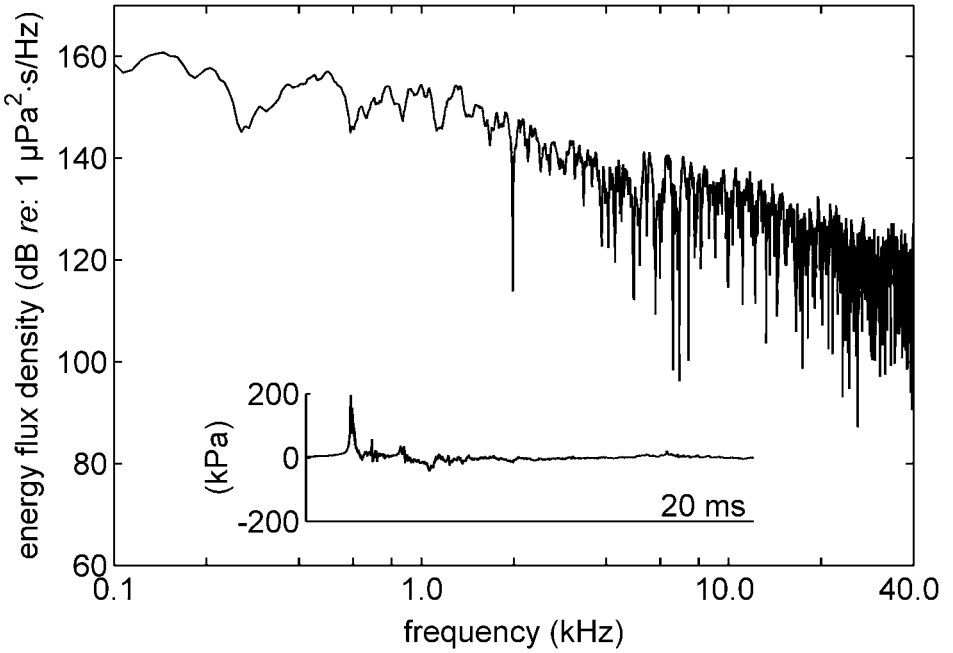
- Distant pressure signatures
  - Multipath propagation, reflection, refraction



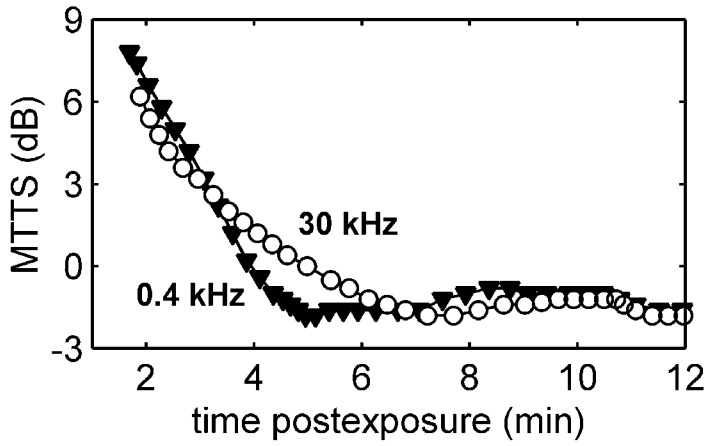
Impulse Exposure Odontocetes (watergun)

- **Finneran et al. (2002)**

- Dolphin - no MTTS at highest level
  - **227 dB re: 1 µPa (~ 30 psi, 207 kPa) peak pressure**
  - **188 dB re: 1 µPa^2·s total energy flux**



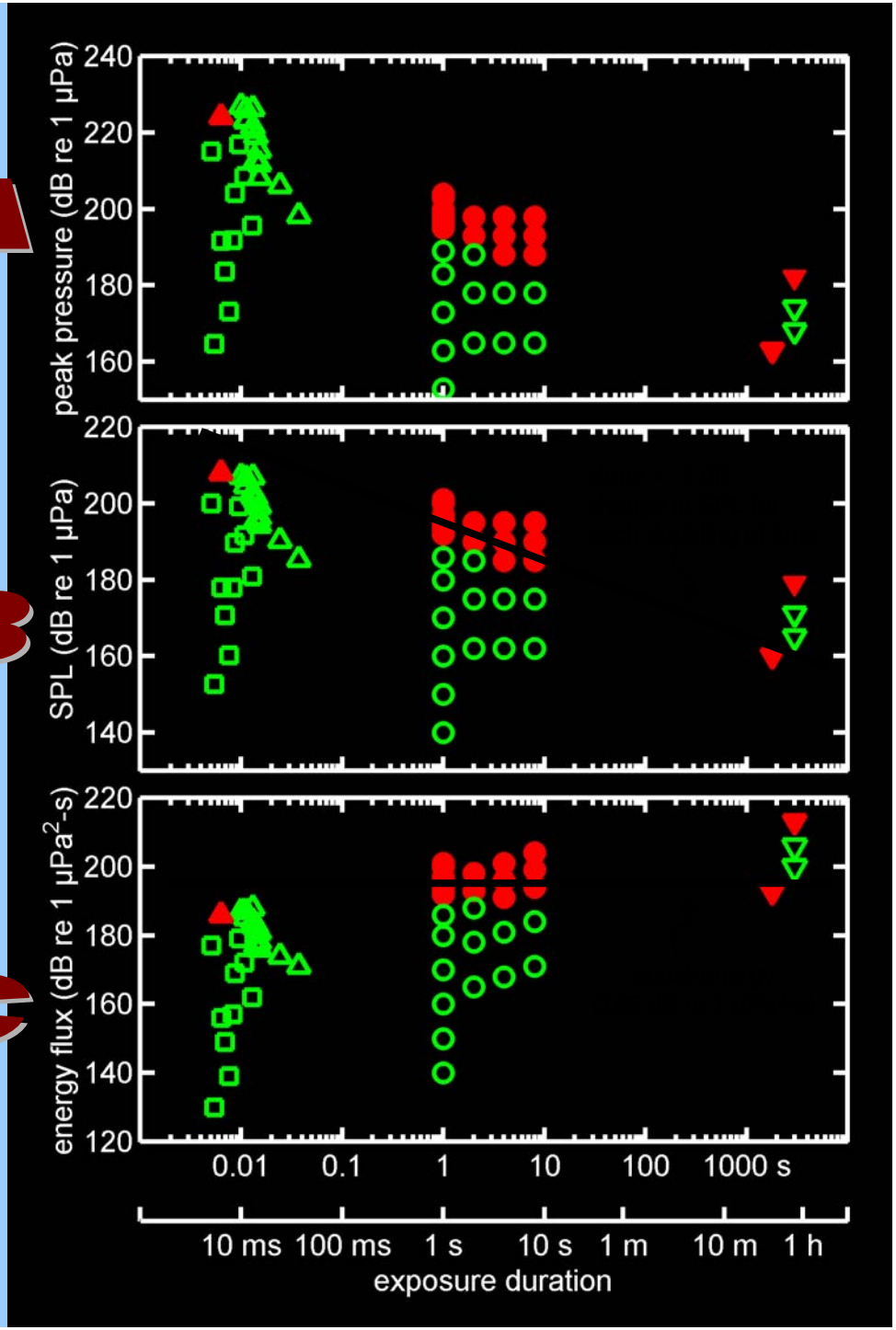
- White whale - MTTS
  - **224 dB re: 1 µPa (~ 23 psi, 160 kPa) peak pressure**
  - **186 dB re: 1 µPa^2·s total energy flux**

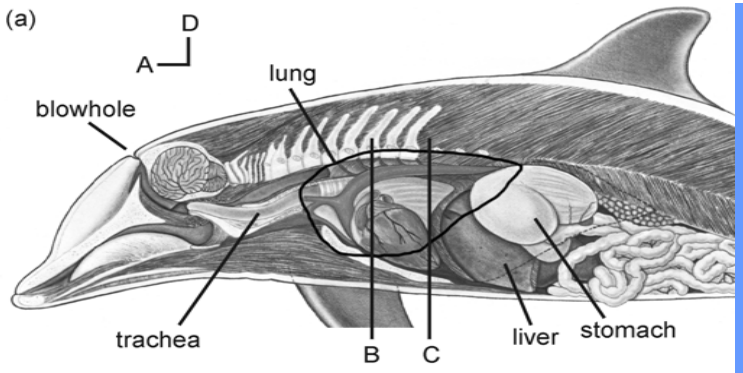


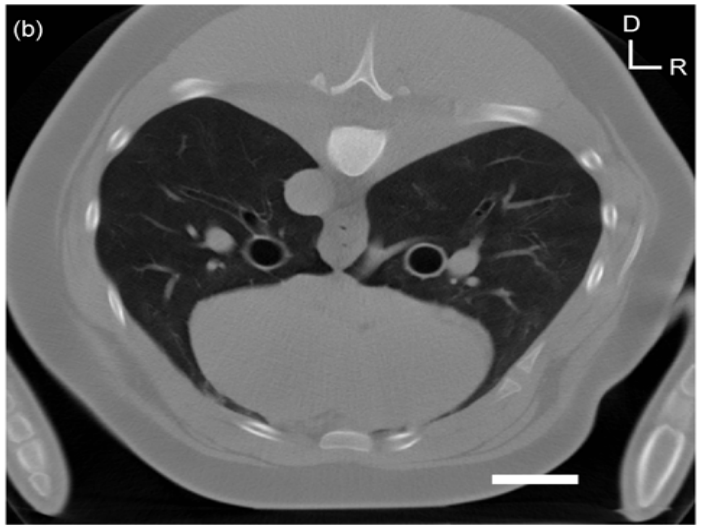
Marine Mammal TTS Data:

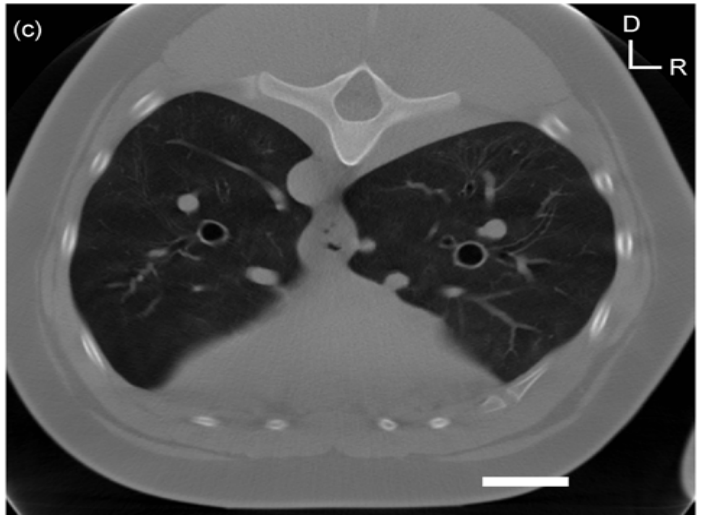
Cetaceans

- TTS depends on sound pressure and duration
  - Shorter duration exposures require higher sound pressures for comparable effects
- Slope of -3 dB SPL per doubling of time fits existing data
  - Equivalent to an “equal-energy” line at 195 dB re 1 μPa^2-s

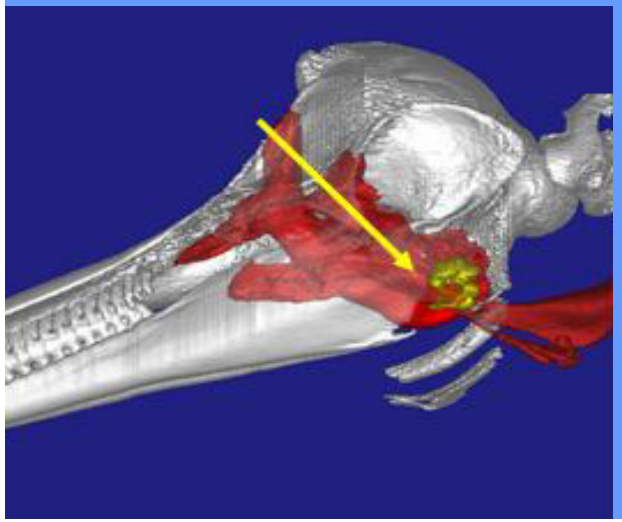


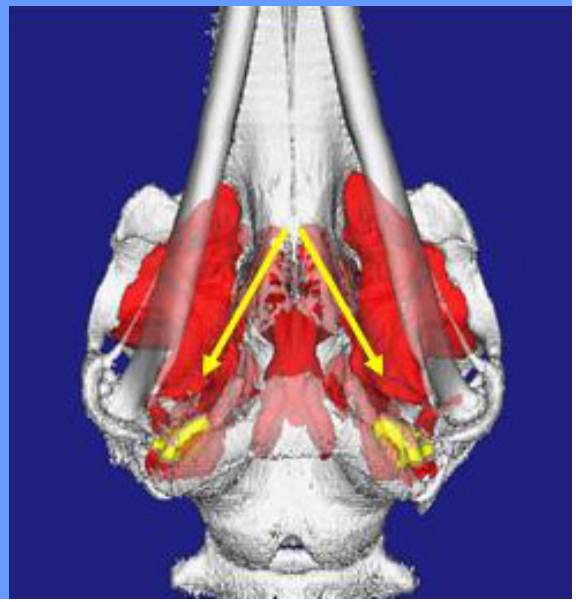


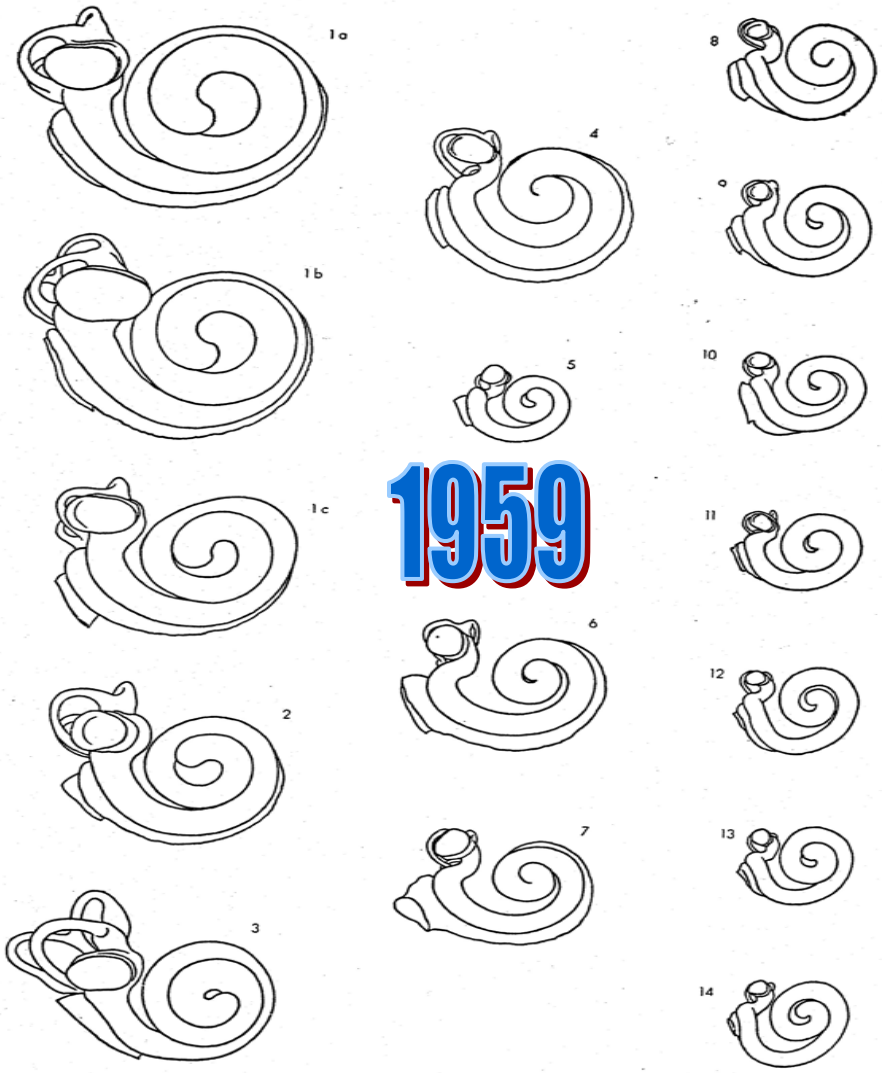




Gas in Lungs, Sinuses, and intestine is Acoustically Reflective



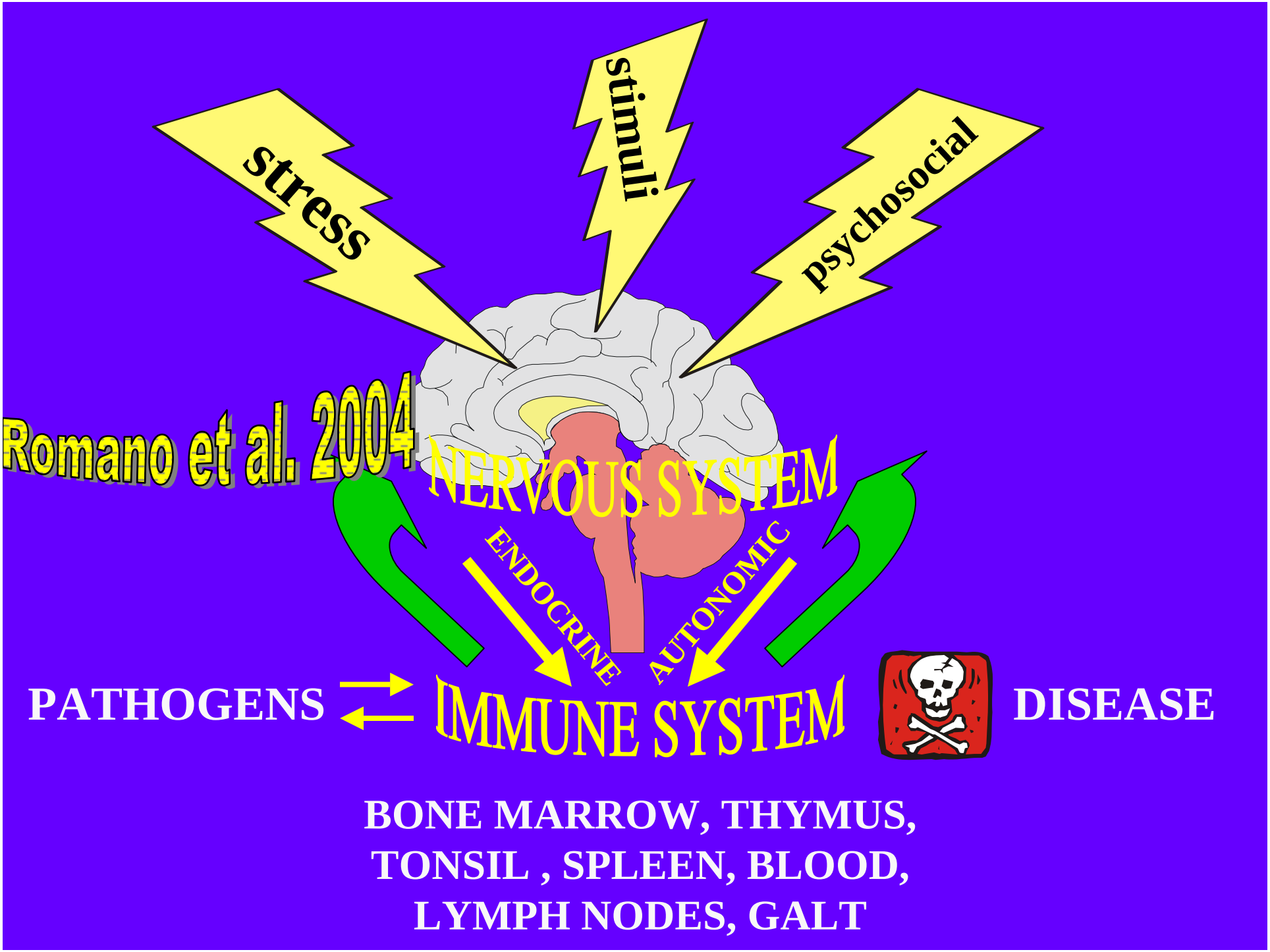




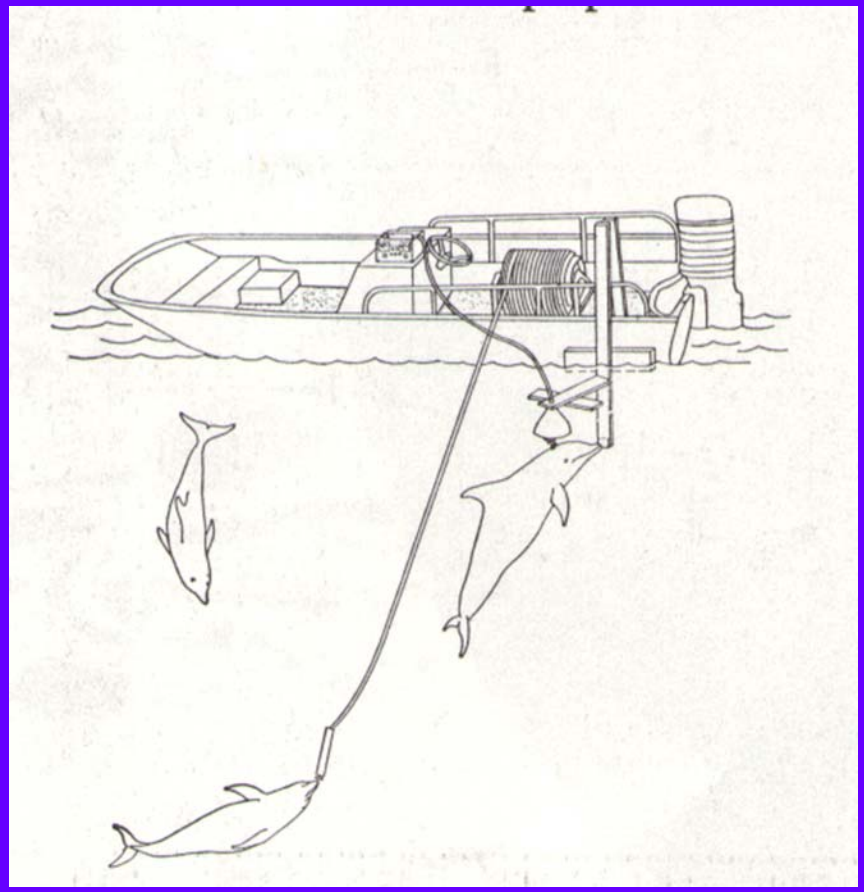
Text-fig. 1. Cast specimens of cetacean labyrinths (1.5×). The modiolus of cochlea is situated upright in all the drawings so that the number of turns of each may be estimated according to the reader's criteria. 1–a. *Balaenoptera musculus*; 1–b. *B. physalus*; 1–c. *B. borealis*; 2. *Megaptera*; 3. *Eubalaena*; 4. *Physeter*; 5. *Kogia*; 6. *Berardius*; 7. *Ziphius*; 8. *Globicephala*; 9. *Grampus*; 10. *Feresa*; 11. *Lagenorhynchus*; 12. *Delphinus*; 13. *Prodelphinus*; 14. *Neomeris*.

1959

In our studies of TTS we noticed what may have been a vestibular Tullio phemonenon for dolphins when stimuli were around 200 dB re 1 micro-Pascal for 1 second

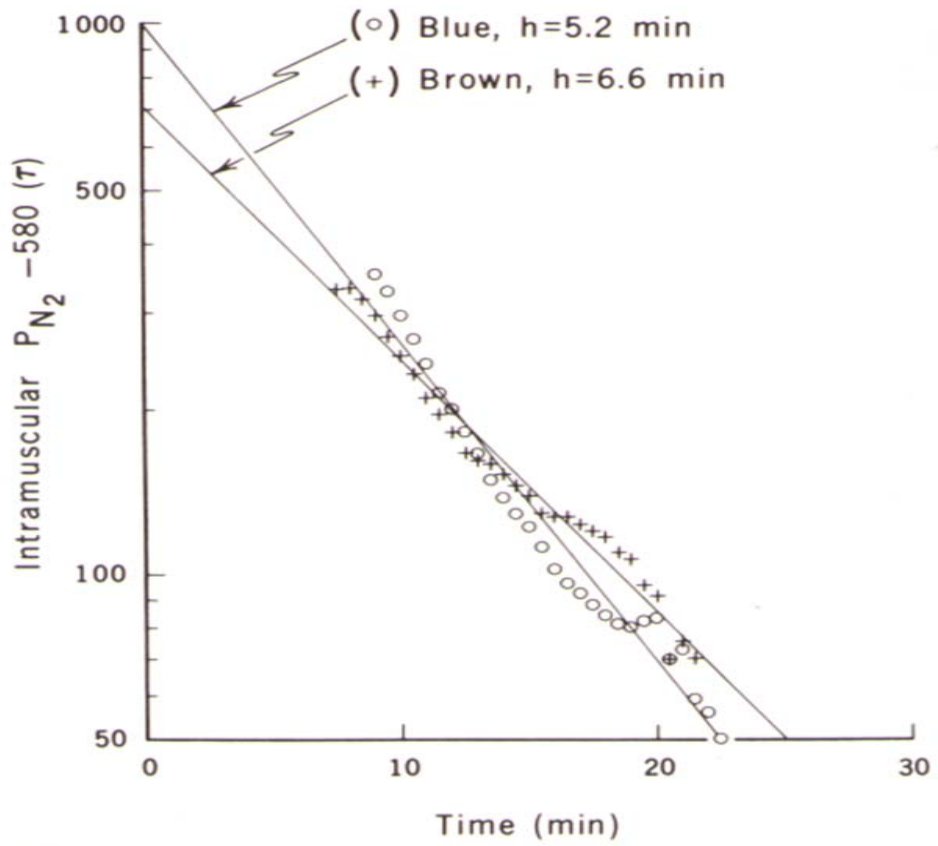

stress
stimuli
psychosocial
Romano et al. 2004
NERVOUS SYSTEM
ENDOCRINE
AUTONOMIC
PATHOGENS
IMMUNE SYSTEM
DISEASE
BONE MARROW, THYMUS,
TONSIL , SPLEEN, BLOOD,
LYMPH NODES, GALT

Deep Dive With Lung Full of Air Followed by Lung Air Exhalation

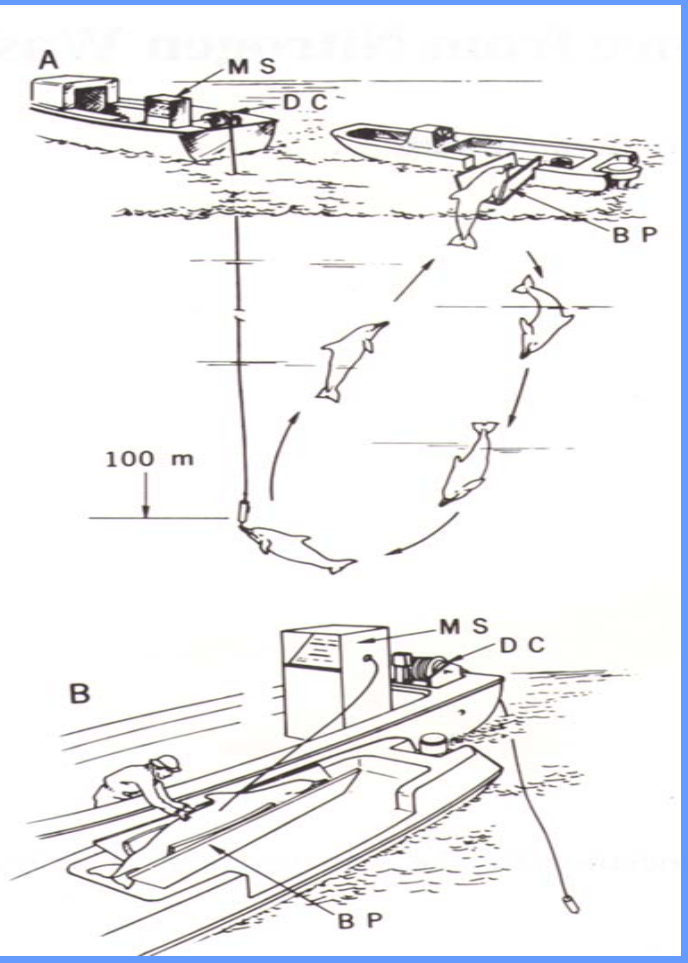


Dolphin Chest Compression at Depth

Ridgway and Howard (1979)



Nitrogen washout and nitrogen half-time determined through N_2-tension measured in the muscle of dolphins following completion of a dive bout.



Mass spectrometer measurement of N_2-tension in the muscle of a bottlenose dolphin following a series of dives to 100 m.

Liver diagram (Slijper, 1962) with photograph of liver “bubbles” courtesy of Paul Jepson 2003.

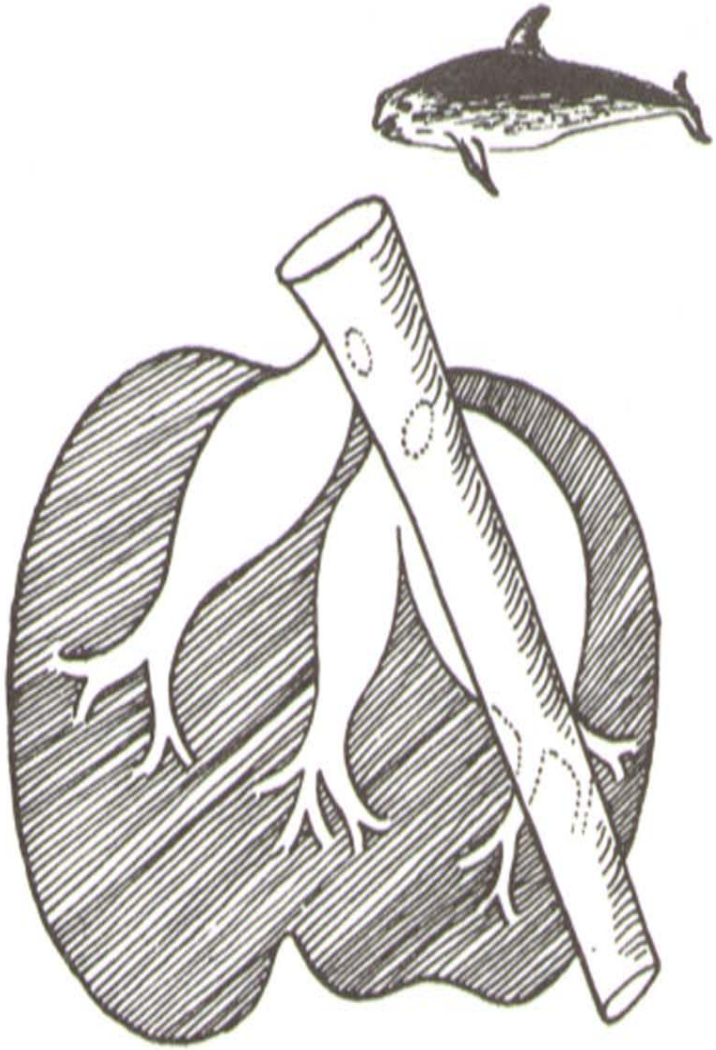
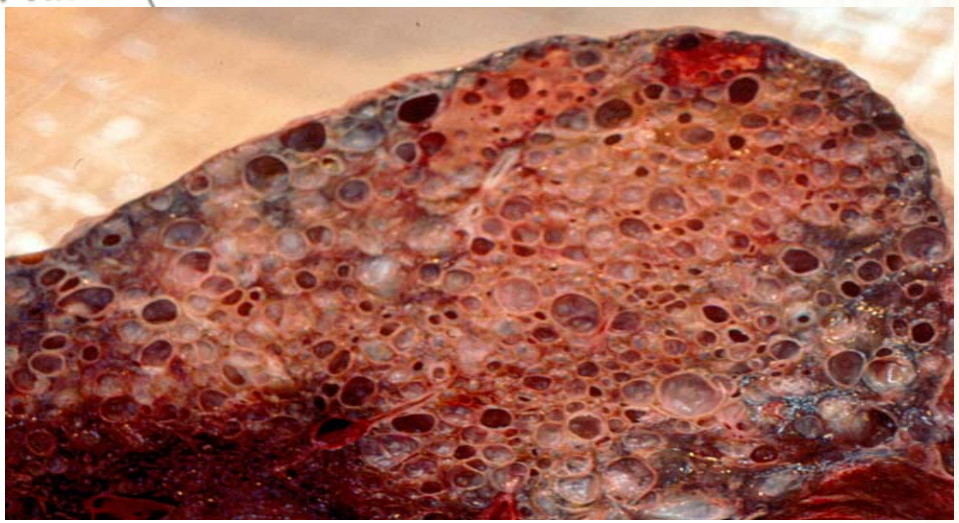


Figure 96. Highly diagrammatic rear view of the liver of Risso's Dolphin, showing position of distended hepatic veins and their connexion with the posterior vena cava. (Richards and Neuville, 1896.)



liver

Veins and Arteries (Slijper, 1962)

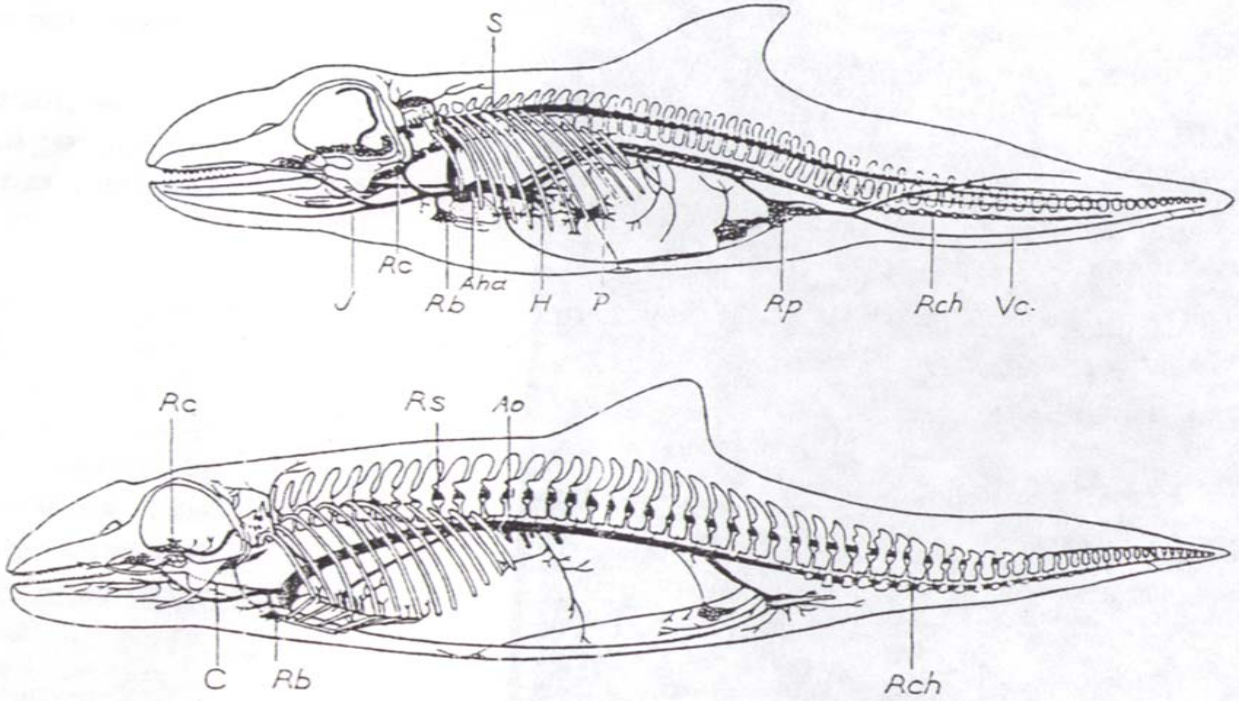
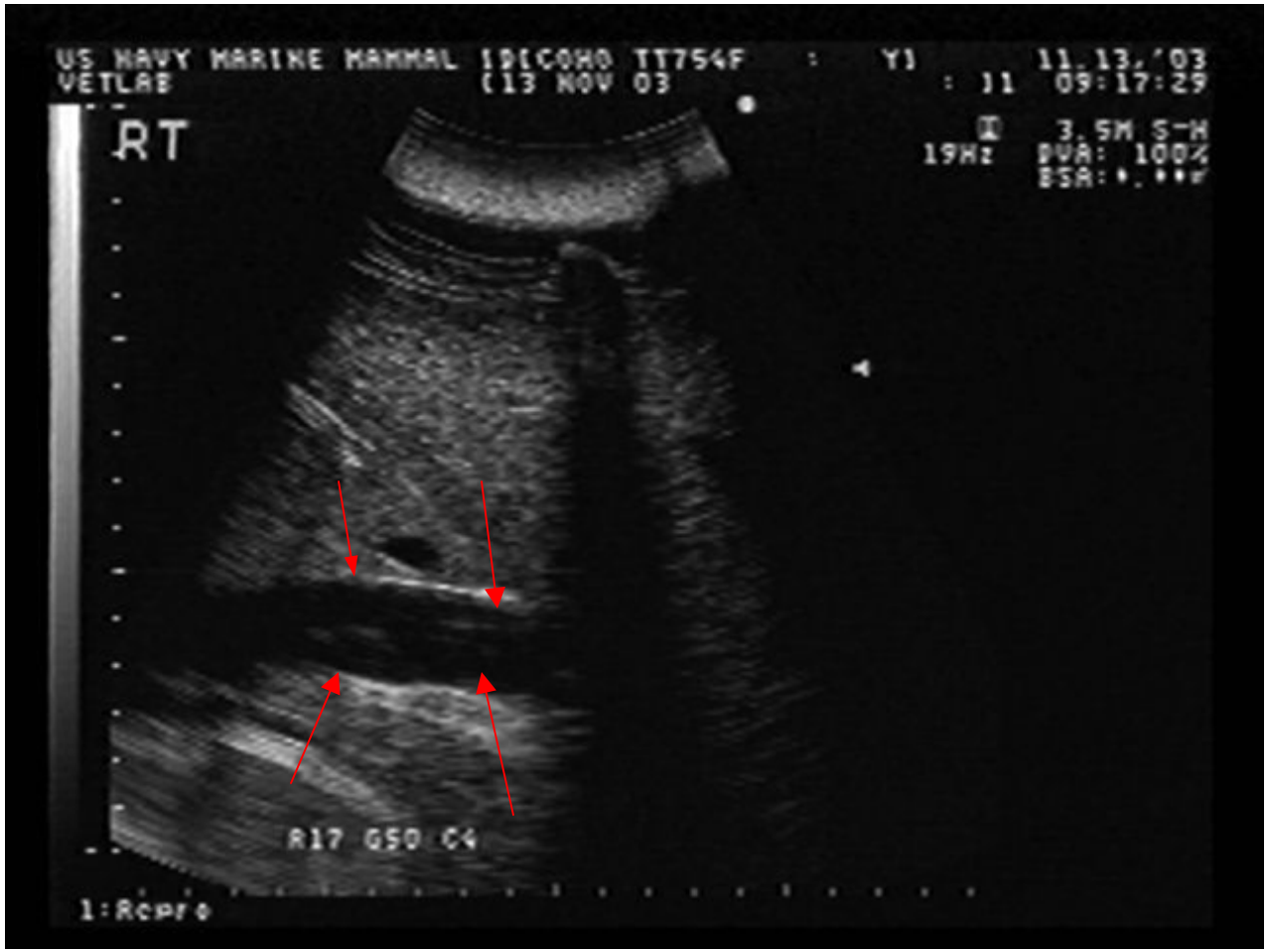


Figure 95. Top: The main veins and their retia in a porpoise. (The cervical and thoracic retia are not shown.) J = jugular vein; Rb = brachial rete; Rc = basi-cranial rete; Aha = anterior vena cava; H = hepatic vein; P = portal vein; S = spinal vein; Rp = pelvic rete; Rch = chevron-canal rete; Vc = superficial caudal vein. (Slijper, 1936.) Bottom: The main arteries and some retia in a porpoise. (The cervical and thoracic retia are not shown.) Rc = cranial rete; C = partially closed internal carotid artery; Rb = brachial rete; Rs = spinal rete crossed by two arteries carrying blood to the brain cavity; Ao = aorta; Rch = chevron canal rete. (Slijper, 1936.)

Dolphin Liver Ultrasound

Large vein (arrows) between two rib shadows is readily imaged



Movie:Dive Series Followed by Ultrasound Exam For Bubbles

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